JAPANESE [JP,2002-300001,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

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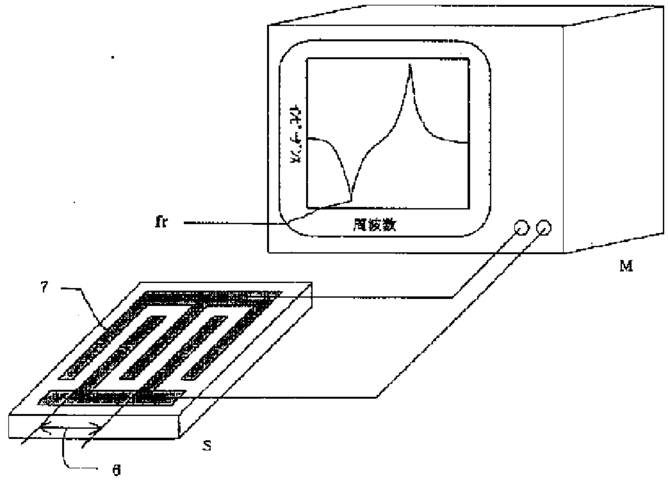
DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the substrate for surface acoustic wave apparatus which comprises a lithium tantalate single crystal, the surface acoustic wave apparatus using it, and its manufacturing method.
[0002]
[Description of the Prior Art]A lithium tantalate single crystal (henceforth LT) is widely used as electronic parts or a substrate material of an optoelectronic device, and is used suitably for the substrate of the surface acoustic element used for the communication equipment represented especially with recent years by the cellular phone etc., or information machines and equipment.
[0003]Wafer (wafer) which comprises a lithium tantalate single crystal is produced by the almost same method as the manufacturing process of the semiconductor single crystal wafer represented by the silicon single crystal. Namely, after raising a crystal by the melt raising method, the outer diameter of a crystal is rounded off and processed, It is cut so that crystal orientation required for a wafer may be obtained, and it is produced through rough grinding, chamfering work, and the process of mirror polishing one by one (see the Showa 53(1978) issue TOSHIBA REVIEW 33 volume 9 No. 761-763 page).
[0004]On the other hand, the miniaturization of structure follows the surface acoustic wave device using an LT wafer with high-frequency-izing, and the fall of the manufacturing yield poses a problem. To manufacture a device with the sufficient yield using a large caliber wafer with low-pricing of devices is desired. Although the homogeneity of the elastic surface acoustic wave velocity of a wafer influences the yield of a surface acoustic wave apparatus sensitively especially, It was common

Drawing selection Representative draw



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by measuring elastic surface acoustic wave velocity and Curie temperature with correlation by thermometric analysis etc. conventionally to have managed the homogeneity of elastic surface acoustic wave velocity (see JP,S61-127219,A).

[0005]

[Problem to be solved by the invention]According to JP,S61-127219,A, the surface wave speed homogeneity within the conventional wafer surface has a crystal presentation and correlation, for example, but since the quantitative-analysis accuracy of a presentation is low, managing with Curie temperature with a presentation and correlation is proposed.

[0006]However, in the thermometric analysis used for a curie temperature survey, since about **1.5 ** of errors of measurement are expected, it can never be said that it is high-precision. Since especially the frequency of the surface acoustic wave filter used for a cellular phone in recent years rose even on the G Hz belt, the minimum electrode size of the device was miniaturized to 1/15 and the submicron order was reached, Dispersion in elastic surface acoustic wave velocity will link with a yield fall directly, and it has become important [management of elastic surface acoustic wave velocity] further [it]. In thermometric analysis, in order for measurement to take several hours, the efficiency of wafer sorting was a problem bad.

[0007]Then, this invention is proposed in view of many above-mentioned problems, and is a thing.

The purpose is to provide the substrate for surface acoustic wave apparatus which comprises a ** lithium tantalate single crystal, the surface acoustic wave apparatus using it, and its manufacturing method.

[0008]

[Means for solving problem]In order to solve an aforementioned problem, in the extraordinary index which measured the substrate for surface acoustic wave apparatus of this invention at the temperature of 20-30 ** using helium-Ne laser, 2.1767-2.1795, or a double reflex value comprises the lithium tantalate single crystal of 0.0004-0.0032.

[0009]It is especially characterized by change of said extraordinary index or said double reflex value being **0.0003.

[0010]It is characterized by the principal surfaces of a substrate being 33 degrees - a 46-degree rotation Y cut face.

[0011]The surface acoustic wave apparatus of this invention formed the excitation electrode of the surface acoustic wave on the substrate for surface acoustic wave apparatus.

[0012]As for this invention, the manufacturing method of the surface acoustic wave apparatus of this invention is characterized by that the temperature of 20-30 ** comprises the following again to the substrate which comprises a lithium tantalate single crystal.

The process of measuring an extraordinary index or a double reflex value using helium-Ne laser.

The process as which 2.1767-2.1795, or said double reflex value chooses the substrate of the lithium tantalate single crystal of 0.0004-0.0032 in said extraordinary index.

The process of forming the excitation electrode of a surface acoustic wave on the selected substrate.

[0013]

[Mode for carrying out the invention]Below, the manufacturing method of the lithium tantalate single crystal wafer suitably used, for example as a piezoelectric board of the surface acoustic wave filter of a cellular

phone and the management method of an especially uniform surface acoustic wave are explained in detail based on the Drawings illustrated typically.
[0014]Since it was closely related with the frequency of a surface acoustic wave apparatus, and the refractive index whose speed of a closely related surface acoustic wave is an optical property, it investigated in detail about the wafer substrate direction widely used for the cellular phone etc. which are used with a high frequency band.
[0015]As a result, it turned out that it becomes possible to manufacture the high surface acoustic wave apparatus of the yield whose characteristic was fixed by sorting out the refractive index or double reflex value of an extraordinary ray so that it may become within the limits of specification.
[0016]One side produces the wafer by which mirror polishing was carried out through a wafer processing process from the LT monocrystal which pulled up in detail and was raised. Then, the extraordinary index in a wafer and between a wafer is measured using helium-Ne laser (wavelength of 632.8 nm) under environment with a temperature of 20-30 **, An extraordinary index sorts out a wafer so that 2.1767-2.1795, and the change within the field may be set to **0.0003, and use for a device process, or by or the same measuring condition. The double reflex value of a lithium tantalate single crystal wafer uses for a device process only the wafer in which the change was sorted out by 0.0004-0.0032 by the range of **0.0003. the surface acoustic wave apparatus of high yield with which the surface acoustic wave apparatus manufactured has by this the characteristic that dispersion in frequency is small and constant -- production -- things are made.
[0017]The device process would be manufactured using big-ticket equipment as the electrode structure of the excitation electrode of the surface acoustic wave formed on a substrate became detailed, the amount of capital investment will occupy the great portion of cost price of a surface acoustic wave apparatus, and the improvement in the yield by a device process was the most important.
[0018]Thus, a manufacturing method of a surface acoustic wave apparatus of this invention is provided with the following.
A process of measuring an extraordinary index or a double reflex value at temperature of 20-30 ** to a substrate which comprises a lithium tantalate single crystal using helium-Ne laser.
A process as which 2.1767-2.1795, or a double reflex value chooses a substrate of a lithium tantalate single crystal of 0.0004-0.0032 in an extraordinary index.
A process of forming an excitation electrode of a surface acoustic wave on a selected substrate.

[0019]Based on a right-handed rectangular coordinate system shown especially in drawing 4, a lithium tantalate single crystal wafer whose angles of rotation theta are 33 degrees - 46 degrees is widely used for a surface acoustic wave apparatus for high frequency, since it has submicron detailed electrode structure, yield reservation is an important problem, and an effect is greatest.
[0020]Here, nine in a figure shows Y cut face, 8 shows a theta rotation Y cut face, and theta shows an angle of rotation (degree), respectively. Drawing 1 shows an extraordinary index of a wafer, and a rate of change in elastic surface acoustic wave velocity to a double reflex value. As for the characteristic of 2a and 2b, and 36-degree rotation Y cut substrates,

the characteristics of 4a and 4b, and 46-degree rotation Y cut substrates of the characteristic of 3a and 3b, and 42-degree rotation Y cut substrates are [the characteristic of 33 degree rotation Y cut substrates] 5a and 5b.
[0021]From the relation between an extraordinary index, and the double reflex value and elastic-surface-acoustic-wave-velocity rate of change of the characteristic shown in drawing 1, the numerical limitation antecedent basis of the extraordinary index and the double reflex value had the large rate of change of elastic surface acoustic wave velocity, and computed as a minimum 0.15% to which the device yield is reduced.
[0022]Measurement of the refractive index was measured with the prism coupling process shown in drawing 2. In the optical path 1 reflected by the reflective critical angle alpha of the laser beam in a contact surface with the prism np of the refractive index np in contact with the surface of the wafer S which comprises a lithium tantalate single crystal, the extraordinary index ne of a wafer and double reflex value **n are called for from a following formula by np and alpha.
[0023]ne=np sintheta (however, it is a case where the optic axis of LT and the polarization direction of laser are in agreement, and the refractive index of the ordinary light which rotated 90 degrees of polarization directions to this is described as no)
A **n=|no-ne| elastic-surface-acoustic-wave-velocity rate of change is searched for from the system of measurement shown in drawing 3. . Namely, were provided on the wafer which comprises a lithium tantalate single crystal. The electrical property acquired by impressing high frequency voltage to the electrode (IDT electrode) 7 of the pectinate form which is an excitation electrode of a surface acoustic wave is measured using the network analyzer M, and it asks for elastic surface acoustic wave velocity by the product of the resonance frequency fr and electrode period 6. It is the elastic-surface-acoustic-wave-velocity rate of change which was expressed with the ratio from the elastic surface acoustic wave velocity made into the standard of the elastic-surface-acoustic-wave-velocity variation between the wafers within a wafer surface.
[0024]
[Working example]Next, the more concrete embodiment of this invention is described.
[Example 1] The manufacturing method of a 42-degree rotation Y cut lithium tantalate single crystal wafer is explained. It raised with annealing, having made LT raw material melt of the harmony presentation of the seed crystal of a direction vertical to a wafer cut contact, and rotating, and the single crystal of the diameter of about 100 mm was obtained. The both ends of the crystal were cut in the 42-degree rotation Y cut face using an inner periphery edge cutting machine and X-ray diffractometer.
[0025]Next, silver paste was applied to both cutting planes, and single domain-ized processing was performed, impressing the voltage of 1.5-5v/cm to inter-electrode at 700 ** more than Curie temperature with an electric furnace. The wafer which gave cylindrical grinding, slice, rough grinding, chamfering, and mirror polishing and in which mirror polishing of one side was carried out in the single-domain--ization-processed crystal ingot was produced.
[0026]
[Table 1]

実施例	面内の異常光屈折率	面内の複屈折値	弾性表面波速度変化率（%）	周波数±0.15%歩留り（%）
1	2.1780±0.0005	0.0017±0.0005	0.12～0.35	42
2	2.1783±0.0004	0.0020±0.0004	-0.01～0.22	88
3	2.1784±0.0003	0.0021±0.0003	-0.02～0.13	100
4	2.1785±0.0002	0.0022±0.0002	-0.02～0.03	100
5	2.1786±0.0004	0.0023±0.0004	-0.18～0.02	94
6	2.1789±0.0005	0.0026±0.0006	-0.09～0.36	69

[0027]The result of having made the yield of the rate of change in a wafer and elastic surface acoustic wave velocity and less than **0.15% of frequency which changed the extraordinary index and double reflex value within a field contrasting is shown in Table 1. It turned out that the rate of change in elastic surface acoustic wave velocity fluctuates corresponding to an extraordinary index and the amount of double reflex value changes, and the frequency yield is also further fluctuated according to this. It is drawing 1 which showed the relation also including the data about 33 degrees - 46-degree rotation Y cut substrates at this to the graph, and it became clear that it was in proportionality.
[0028]If the rate of change of elastic surface acoustic wave velocity exceeds 0.15% on experience in device manufacturing processes especially, in order to reduce the yield of a surface acoustic wave apparatus greatly, An extraordinary index is measured using helium-Ne laser (wavelength of 632.8 nm) under environment with a temperature of 20-30 **, and the change within the field should be **0.0003 in 2.1767-2.1795. Or it turned out that it can attain because the double reflex value of a lithium tantalate single crystal wafer uses the wafer in which change was sorted out by 0.0004-0.0032 by the range of **0.0003 on the measuring condition.
[0029]An extraordinary index and a double reflex value that an elastic-surface-acoustic-wave-velocity rate of change will be less than 0.15% from drawing 1 if it explains still in detail by 33-degree rotation Y cut by 2.1767-2.1773 and 0.0004 - 0.001 or 36-degree rotation Y cut 2.1772-2.1778. And in a 0.0009 - 0.0015 or 42-degree rotation Y cut, it is a range in which 2.1789-2.1795, and 0.0026-0.0032 have an effect in a 2.1782-2.1788 and 0.0019 - 0.0025 or 46-degree rotation Y cut.
[0030]These measuring methods are explained. The speed of a surface acoustic wave produces the resonator of Kushigata typically shown in drawing 3 by a device process, The resonance frequency fr was measured using the prober (product made from GGB 40 A-GSG-250-DB), and the network analyzer (8753D by Hewlett Packard), and it calculated from the product of fr and the wavelength lambda. With the prism coupling process shown in drawing 2, the extraordinary index ne and double reflex value **n were computed from the following formula using the refractive index np of prism, and the degree theta of total-internal-reflection critical incidence angle of laser. In particular, measured value was proofread using the LaSF35 high-refractive-index glass made from SCHOTT (n632.8=2.01493).
[0031]The result, As shown in Table 1 and drawing 1, elastic surface acoustic wave velocity and an extraordinary index. And a double reflex value has correlation and an extraordinary index when the change within the field sorts out **0.0003 or a double reflex value by 0.0004-0.0032 and change sorts out it in **0.0003 by 2.1767 and 2.1795 resulting. It becomes possible to sort out beforehand the rate of change of elastic surface acoustic wave velocity within 0.15% which is a limit of a

frequency yield fall of a surface acoustic wave apparatus. Especially in 33 degrees - the 46-degree rotation Y cut direction which are widely used as a high frequency surface acoustic wave apparatus of a G Hz belt, it turned out that this is effective.

[0032]Compared with the selecting method of the wafer by the Curie temperature which measurement took time conventionally and in which a problem was also in the accuracy of measurement by this, the wafer for surface acoustic wave apparatus can be sorted out with high precision easily in a short time.

[0033]

[Effect of the Invention]As mentioned above, according to this invention, at the temperature of 20-30 **, the extraordinary index measured using helium-Ne laser uses the substrate for surface acoustic wave apparatus with which 2.1767-2.1795, or a double reflex value comprises the lithium tantalate single crystal of 0.0004-0.0032. Change of an extraordinary index or said double reflex value uses the substrate for surface acoustic wave apparatus which is **0.0003. The principal surface of a substrate uses the substrate for surface acoustic wave apparatus which are 33 degrees - a 46-degree rotation Y cut face. In the temperature of 20-30 ** to the substrate which comprises a lithium tantalate single crystal further again, The process of measuring an extraordinary index or a double reflex value using helium-Ne laser, Said extraordinary index performs manufacture including the process as which 2.1767-2.1795, or said double reflex value chooses the substrate of the lithium tantalate single crystal of 0.0004-0.0032, and the process of forming the excitation electrode of a surface acoustic wave on the selected substrate.

[0034]Thereby, compared with the conventional method, wafer sorting can be performed simple for a short time. The surface acoustic wave apparatus produced using the wafer sorted out has the good characteristic, since a uniform substrate can be manufactured to high yield, and it can reduce a manufacturing cost and also can reduce a defect, reduces wastes and can expect the effect of environmental protection.

[Translation done.]